OCR Computer Science A Level

1.3.3 Networks

Advanced Notes

Specification

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1.3.3 b)

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Networks and Protocols

Characteristics of a network

A network is the name given to two or more computers connected together with the ability to transmit data between each other. There are two main types of networks: local area networks and wide area networks.

Local area network (or LAN) is the name given to a network which is spread over a small geographical area or a single site, for example: a school. A wide area network (or WAN) is the name given to a network which is spread over a large geographical area. Large corporations with offices in multiple locations will often have a WAN allowing them to communicate between different sites.

Protocols

A protocol is a set of rules defining how two computers communicate with each other. Protocols are standard so that all devices have a designated method of communicating with each other, regardless of manufacturer.

Examples of commonly used protocols are:

- HTTP (Hypertext Transfer Protocol) – Used for web page rendering, an encrypted version, HTTPS (Secure), is becoming more common
- TCP/IP (Transmission Control Protocol / Internet Protocol) – This is a networking protocol used in the routing of packets through networks
- POP3 (Post Office Protocol) and IMAP (Internet Message Access Protocol) – Mailing protocols, used for email access.
- FTP (File Transfer Protocol) – Used for the transmission of files over networks.

The Internet Structure

The Internet is a network of networks which allows computers on opposite sides of the globe to communicate with each other. Continents are connected to each other using large international backbone cables. Many of these pass underwater, linking continents to one another.

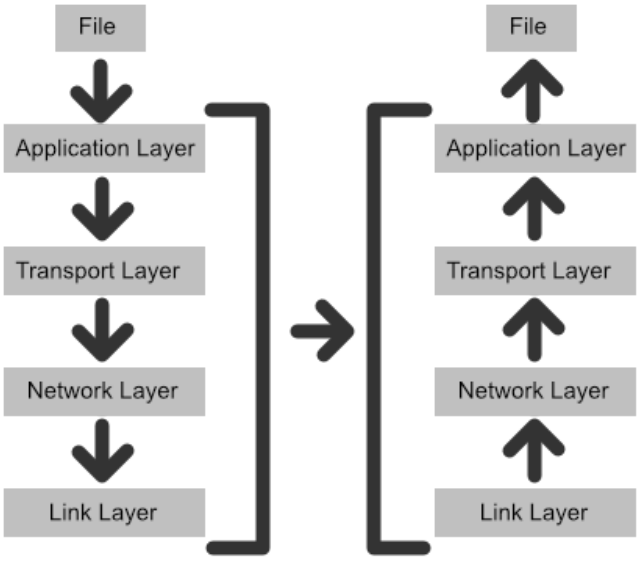
The TCP/IP Stack and protocol layering

TCP/IP stands for Transmission Control Protocol / Internet Protocol. A stack of networking protocols that work together passing packets during communication, they work as follows:

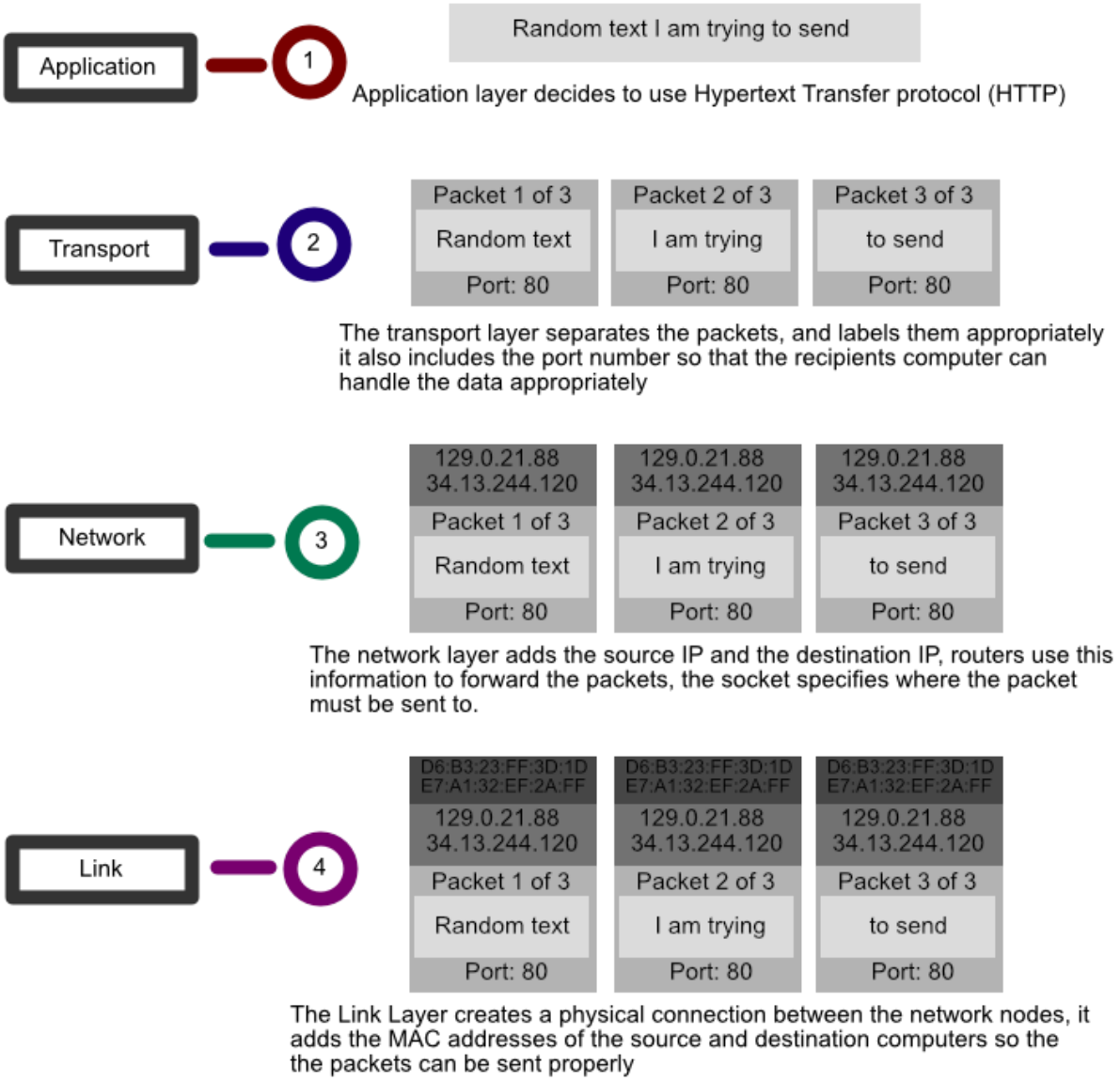
- Application Layer
  - The application layer is based at the top of the stack. It specifies what protocol needs to be used in order to relate the application that's being sent.
  - For example, if the application is a browser then it would select a protocol such as HTTP, POP3, FTP

- Transport Layer
  - The transport layer uses TCP to establish an end-to-end connection between the source and recipient computer.
  - The transport layer splits data up into packets and labels these packets with their packet number, the total number of packets the original data was split up into and the port number being used for communication.
  - If any packets get lost, the transport layer requests retransmissions of these lost packets.
- Network Layer
  - The network layer adds the source and destination IP addresses. (The combination of the IP address and the port number is called a socket address.)
  - Routers operate on the network layer and the router is what uses the IP addresses to forward the packets.
  - The sockets are then used to specify which device the packets must be sent to and the application being used on that device.
- Link Layer
  - The link layer is the connection between the network devices, it adds the MAC address identifying the Network Interface Cards of the source and destination computers.
  - For devices on the same network, the destination MAC address is the address of the recipient computer, otherwise, it will be the MAC address of the router.

It's important to realise that this is a stack. On the recipient's computer these layers are looked at from bottom to top. Once the destination has been reached, the MAC address is removed by the link layer, then the IP addresses are removed by the Network Layer, then the transport layers remove the port number and reassemble the packets. Finally, the application layer presents the data to the recipient in the form it was requested in.



On the next page is a diagram showing exactly what happens in the process of sending a file.


Application
1
Random text I am trying to send
Application layer decides to use Hypertext Transfer protocol (HTTP)
Transport
2
Packet 1 of 3
Random text
Port: 80
Packet 2 of 3
I am trying
Port: 80
Packet 3 of 3
to send
Port: 80
The transport layer separates the packets, and labels them appropriately it also includes the port number so that the recipients computer can handle the data appropriately
Network
3
129.0.21.88
34.13.244.120
Packet 1 of 3
Random text
Port: 80
Packet 2 of 3
I am trying
Port: 80
Packet 3 of 3
to send
Port: 80
The network layer adds the source IP and the destination IP, routers use this information to forward the packets, the socket specifies where the packet must be sent to.
Link
4
D6:B3:23:FF:3D:1D
E7:A1:32:EF:2A:FF
129.0.21.88
34.13.244.120
Packet 1 of 3
Random text
Port: 80
Packet 2 of 3
I am trying
Port: 80
Packet 3 of 3
to send
Port: 80
The Link Layer creates a physical connection between the network nodes, it adds the MAC addresses of the source and destination computers so the the packets can be sent properly

LANs and WANs

As specified earlier, a LAN is a local area network and a WAN is a wide area network. A LAN is a network spread over a small geographical area while a WAN is typically spread over a large geographical area. Usually, a WAN will require extra telecommunication hardware. Infrastructure used in WANs is owned by third-parties. The largest WAN is the Internet, and is made up of a series of smaller networks.

DNS

The domain name system (DNS) is the system used to name and organise internet resources. It is a hierarchy, in which each smaller domain is separated from the larger domain by a full stop. For example, 'leeds.gov.uk'. TLD stands for Top Level Domain, and 2LD stands for 2nd Level Domain.

Domain names are much easier to remember than IP addresses, which is why they are used to link to servers across the world. The role of the domain name system server (DNS server) is to translate these domain names into IP addresses when we wish to access a website.

Network Communication

Data Packets

Packets are segments of data. They contain various information:

- Header:
  - Sender and recipient IP addresses
    The sender and the recipient's IP addresses act like a postcode, allowing the packet to be delivered to the correct destination and enabling the recipient device to trace where the packet came from.
  - Protocol being used
    The protocol allows the recipient computer to understand how to interpret the packet.
  - Order of the packets
    Upon arriving at the recipient device, packets are reconstructed in the appropriate order as specified in the header.
  - Time To Live / Hop Limit
    The Time To Live (TTL), tells the packet when to expire so that it does not travel forever.
- Payload
  - Raw data to be transmitted
- Trailer
  - Checksum, or cyclic redundancy check
    The trailer contains a code used to detect whether any errors have occurred during transmission.

Circuit Switching and Packet Switching

There are two techniques using which networks exchange data: circuit switching and packet switching.

Packet switching is a method of communication in which data is communicated using packets across a network. In this method of communication, packets are sent across the most efficient route, which can vary for each packet.

Advantages	Disadvantages
Multiple methods to ensure data arrives intact eg. checksums and cyclic redundancy checks	Time is spent deconstructing and reconstructing the data packets

Multiple routes can be used between devices, so if one path breaks, another can be used.	Must wait for all packets to arrive before data can be received.
Packets can be transferred over very large networks to allow communication globally.	

Circuit switching is a method of communication where a direct link is created between two devices. This direct link is maintained for the duration of the entire conversation between devices. Circuit switching requires the two devices to transfer and receive data at the same rate.

Advantages	Disadvantages
Data arrives in a logical order which results in a quicker reconstruction of the data.	Bandwidth is wasted during periods of time in which no data is being sent.
Enables two users to hold a call without delay in speech.	Devices must transfer and receive data at the same rate.
	Using switches means electrical interference may be produced which can corrupt or destroy data.
	Ties up sections of the network which cannot be used by others data until transmission has been completed

Network Security and Threats

Firewalls

A firewall is a device designed to prevent unauthorised access to a network. A firewall consists of two network interface cards (NICs) between the user and the Internet. The firewall passes the packets between these two NICs and compares them against a set of rules set by the firewall software. The preconfigured rules are called packet filters.

Packet filtering / static filtering limits network access in accordance with administrator rules and policies. It works by examining the source IP, destination IP and the protocols being used as well as the ports being requested.

When access is denied by a firewall, two things can occur. The packet can either be dropped or rejected. A rejected packet sends an alert to the sender to notify them of the error whereas a dropped packet will not.

Proxies
A proxy server acts as an intermediary, collecting and sending data on behalf of the user. There are several benefits of using proxies:

- The privacy of the user is protected and they remain anonymous
- The proxy server can cache frequently used website data making it faster to load
- Proxies can reduce overall web traffic
- Can be used by administrators to prevent access to sensitive or irrelevant information at work or at school

Encryption
Encryption is a way of keeping data secure when transmitting it over the Internet. Encryption makes data unreadable if it is intercepted. Data is encrypted and decrypted using a set of keys.

Synoptic Link

Encryption is a way of mapping data so it's unreadable if intercepted

Encryption is covered in **1.3.1 Compression, Encryption and Hashing**

Network Hardware

Maintaining a network requires various pieces of hardware, some of which are built into devices, such as a network interface card (NIC) while others, like switches, are not.

Network interface cards (NIC)
A network interface card is the card required to connect a device to a network. This is usually built into the device and assigns a unique media access control (MAC) address to each device. The MAC address is a 48-bit value coded into the device and is usually written as a twelve digit hexadecimal number.

Synoptic Link

Hexadecimal is a a number base which uses the numbers 0-9 in addition to the letters A-F.

Hexadecimal is covered in **1.4.1 Data Types**

Switch
A switch is a device used to direct the flow of data across a network. Switches are most commonly used in networks using a star topology.

Wireless Access Point (WAP)
This is a device which allows a device to connect to a network. It is more commonly combined with a router to enable internet access. These are used in mesh networks.

Routers
A router is used to connect two or more networks together. Routers allow private, home networks to connect to the Internet.

Gateway
A gateway is used when protocols are not the same between networks. It translates the protocols so that networks can communicate with each other. Gateways work by removing the header from packets before adding the data to packets using the new protocol.

Client-Server and Peer-to-Peer

Client-server

Client-server networks consist of terminals known as clients connected to a server. The server is a powerful, central computer. The server holds all of the important information and resources and has greater processing power than the terminals. Clients can request to use the server.

Advantages of Client-server	Disadvantages of Client-server
• More secure as data is stored in one location • Central backups are carried out so there is no need for individual backups • Data and resources can be shared between clients	• Relatively expensive to set up • Functionality of terminals depends on the server; if this fails, performance falls • Trained staff are required to maintain the server

Peer-to-Peer

A network in which computers are connected to each other so that they can share files. Each device effectively acts as both a server and client, as it can both provide and request resources. Peer-to-peer networks are used in piracy, since it's almost impossible to trace the origin of files.

Advantages of Peer-to-peer	Disadvantages of Peer-to-peer
• Cheaper to set up • Allows users to share resources • Easy to maintain • Not dependent on a central server • Specialist staff are not required	• Impossible to trace the origin of files • Backups must be performed separately • Poorer security • May be difficult to locate resources